STUDIES IN PALLESTHESIA

Pallometer Threshold Values in 60 Proved Normal Subjects

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Many of the improbable values reported for frequency perception and threshold amplitudes noted in previous vibratory sense studies arise from failure to take into account the fact that significant pallhypesthesia accompanies numerous diseases, in both their active and latent phases, even though there is an absence of demonstrable neurologic pathology (1–3).

Subjects utilized as controls for vibratory sense investigations have frequently suffered from numerous diseases in the acute or convalescent state (4–10).

The present paper reports the pallesthetic threshold patterns at the fingertips in a group composed exclusively of proved *normal* subjects for a selected series of frequencies well within the known perceptible range.

PALLOMETER

The instrument utilized for the determination of threshold values is the "Pallometer", an electronic device specifically designed to produce variations of amplitude in the probe from 0 to 28 microns, in increments of the order of 0.010 microns, at any selected fixed frequencies. Pressures at the test site may be varied from 0 to 250 grams. The servo-mechanism controlling the amplitude of the probe was so constructed that increases in pressure do not change the frequency. The amplitude may be predetermined, adjusted, and regulated with extreme precision and the probe may be applied to any desired location on the body surface.

A simple, harmonic, sine wave is delivered to the skin surface by the probe element, which has a rectilinear reciprocating motion independent of the position of the probe head.

For this investigation a flat circular contactor of 6 mm. diameter at a pressure of 150 grams was used.

A schematic drawing of the oscillator circuits and the probe head is shown in Figure 1.

Ordinary concentration on the part of the subject is required; excessive zeal to answer correctly occasionally causes prolongation of the test. No special education or intelligence requirements are necessary—the apparatus has been used in the routine examination of over 1500 dermatologic patients with few failures. Training designed to familiarize the subjects to recognize the appearance and disappearance of minimal vibratory sensation is carried out before actual test readings are made. The training period varies from 30 to 60 minutes for most normal subjects. To be acceptable, threshold readings in the trained subject must be confirmed within very narrow limits, at least six times.

In conducting the pallometric test particular care is taken to eliminate physical factors causing local or general fatigue, vascular changes or conditions which might produce distraction.

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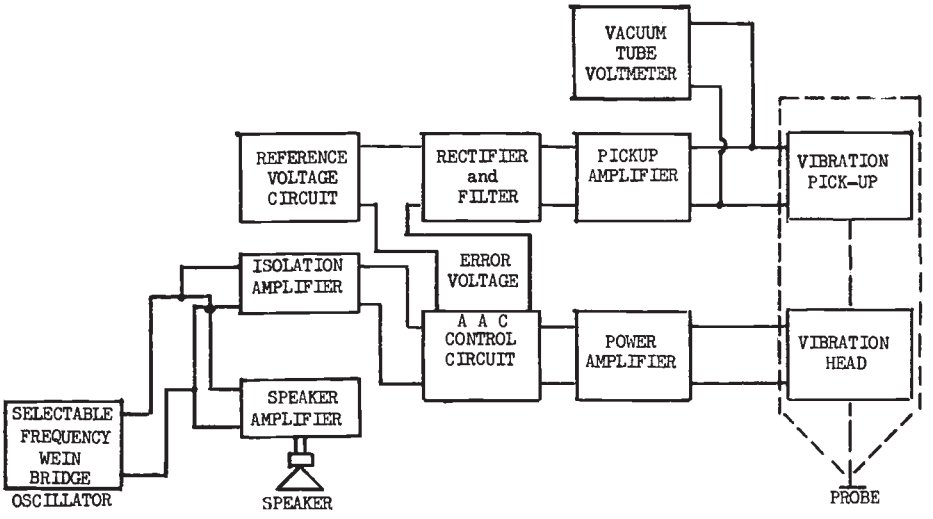


FIGURE 1

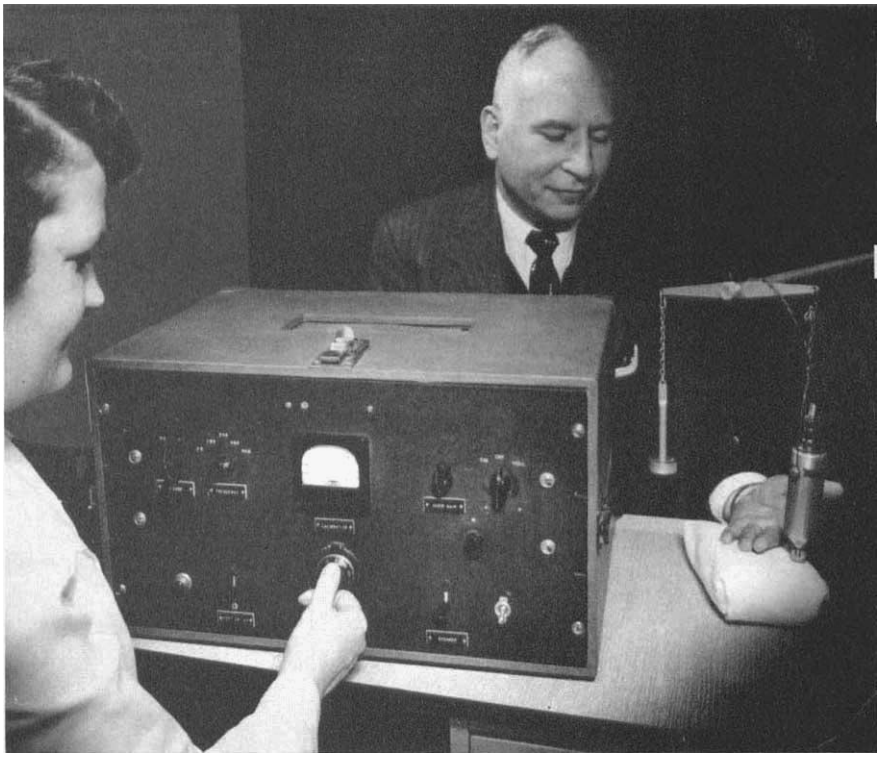
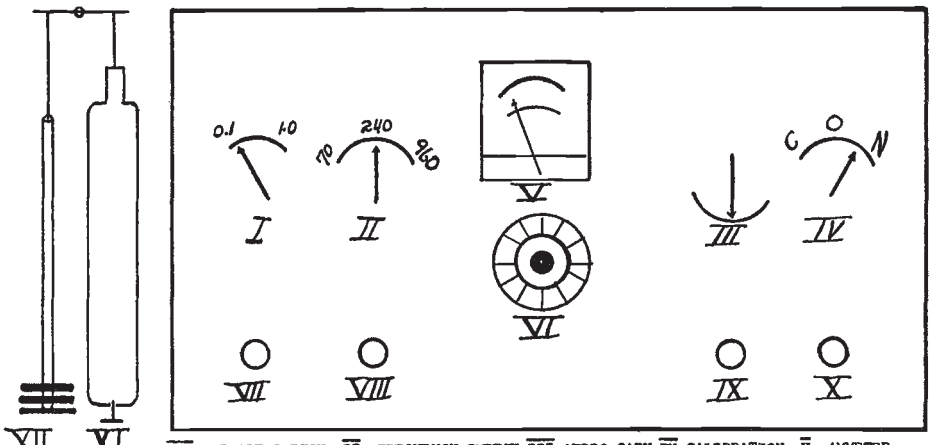


FIGURE 2



I DECADE SWITCH; II FREQUENCY SWITCH; III AUDIO GAIN; IV CALIBRATION; V AMMETER; VI HELIPOT; VII PILOT LIGHT; VIII FOOT SWITCH; IX SPEAKER SWITCH; X OFF-ON SWITCH; XI PROBE CONTACTOR; XII COUNTERBALANCE WEIGHTS.

FIGURE 2a

The subject is seated in a comfortable chair with arm rests. The dorsum of the hand and fingers are supported upon a sponge rubber pillow (Figure 2). The counterbalanced contactor rests perpendicular to the palmar surface of the index fingertip. Threshold amplitudes are determined for the five selected frequencies (70, 120, 240, 480, and 960 c.p.s.) alternately on the left and right index fingertips. During testing, the subjects' *eyes are closed.* Small rest periods are permitted between individual tests.

After a ten minute rest period the entire examination is repeated.

EXPERIMENTAL OBSERVATIONS

The normal status of 42 white and 3 colored females and 15 white males was established by physical and laboratory examinations especially directed to uncovering any diseases causing latent pallhypesthesia. In the preliminary investigation the quantitative vibratory status of the entire surface of the body was investigated with the calibrated tuning fork or "Neurometer" and a stopwatch (Technic 1, 2, and 3). Any subjects showing abnormal neurometric find-

TABLE 1

Mean pallesthetic threshold values on index fingertips

60 proved normal subjects

Frequency c.p.s.	Range mu	Spread mu	Left mu	Right mu	Mean mu
70	.200–.425	.225	.307 ± .061	.310 ± .062	.309 ± .061
120	.070–.170	.100	.092 ± .025	.095 ± .023	.093 ± .025
240	.030–.130	.100	.070 ± .021	.075 ± .021	.073 ± .021
480	.020–.240	.220	.080 ± .069	.087 ± .069	.084 ± .069
960	.010–.310	.300	.085 ± .095	.098 ± .096	.092 ± .093

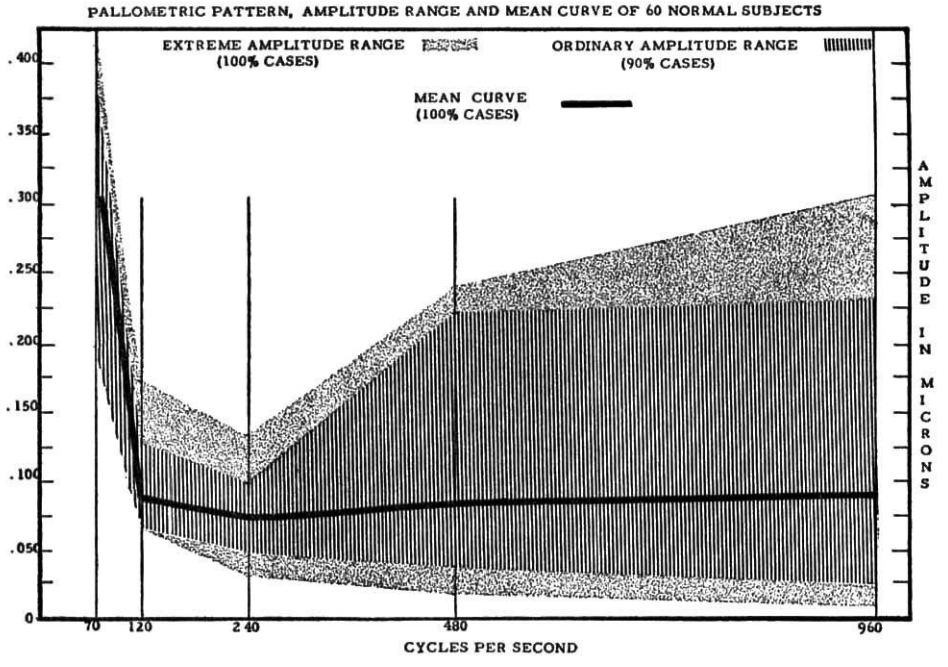


FIGURE 3

ings were automatically excluded from the study while careful questioning eliminated individuals who had received drugs of any type within 1 week previous to the test.

The ages varied from 4 to 59 years with a mean of 31 years. The age group from 18 to 48 years included 85% of the subjects.

The amplitude ranges and mean threshold values at each of the tested frequencies are summarized in Table 1 for the entire group. Figure 3 shows the amplitude ranges of the 90% of cases which demonstrated a normal distribution at all frequencies.

The form of the mean curve (Figure 3) differs considerably from the curves

TABLE 2

Mean pallesthetic threshold values by handedness on index fingertips of proved normal subjects

Frequency c.p.s.	52 Right Handed Subjects			8 Left Handed Subjects		
	Left	Right	Both	Left	Right	Both
			Amplitude in mu			
70	.295	.302	.299	.383	.362	.374
120	.090	.094	.092	.110	.096	.103
240	.066	.073	.070	.095	.085	.090
480	.067	.094	.074	.160	.128	.144
960	.073	.093	.083	.160	.127	.143

TABLE 3

Variations on repeated testing of normal individuals

Case No.	Age	Sex	Race	Test No.	Interval, Days	Frequency, c.p.s.				
						70	120	240	480	960
1	29	F	W	1	—	.265	.096	.065	.045	.040
				2	9	.273	.092	.065	.043	.040
				3	57	.239	.087	.065	.045	.029
				4	70	.244	.089	.067	.048	.021
				5	310	.227	.085	.060	.048	.035
Mean						.250	.090	.064	.046	.035
6	22	F	W	1	—	.325	.093	.065	.075	.090
				2	18	.278	.085	.069	.048	.039
				3	66	.278	.085	.058	.048	.029
				4	73	.250	.085	.061	.045	.032
				5	193	.237	.078	.050	.042	.029
				6	201	.233	.077	.045	.039	.022
				7	202	.251	.080	.050	.042	.022
Mean						.264	.083	.057	.048	.063
10	30	M	W	1	—	.372	.108	.090	.170	.185
				2	3	.385	.107	.094	.170	.212
				3	80	.242	.079	.059	.045	.027
				4	86	.243	.079	.050	.040	.026
				5	94	.243	.079	.050	.040	.026
				6	214	.230	.080	.068	.049	.022
Mean						.295	.089	.069	.086	.083
14	18	F	W	1	—	.242	.167	.110	.210	.180
				2	2	.238	.086	.061	.060	.030
				3	17	.232	.083	.058	.050	.029
Mean						.237	.112	.076	.106	.079
16	18	F	W	1	—	.205	.074	.050	.045	.040
				2	90	.205	.073	.045	.042	.029
				3	91	.205	.071	.040	.042	.029
Mean						.205	.074	.045	.043	.033
21	4	M	W	1	—	.380	.100	.095	.210	.208
				2	18	.375	.108	.090	.215	.200
				3	56	.355	.103	.090	.140	.178
				4	86	.345	.098	.080	.115	.120
				5	161	.333	.092	.074	.090	.045
Mean						.358	.100	.086	.154	.150
57	33	F	C	1	—	.306	.101	.077	.120	.090
				2	7	.321	.097	.080	.130	.125
				3	35	.310	.092	.078	.095	.090
				4	50	.300	.088	.066	.065	.050
Mean						.309	.095	.075	.103	.089

produced by joining the points of the range maxima or minima. The high mean threshold value found at the 70 cycle frequency (.309 μ) decreased rapidly at 120 c.p.s. (.092 μ) and is somewhat further depressed at 240 c.p.s. (.073 μ). Thereafter a gradual rise occurs at 480 c.p.s. (.084 μ) with a further slight

elevation at 960 c.p.s. (.092 μ). The most sensitive (optimum) frequency is noted at 240 cycles but the mean variation from the tested frequencies on either side of this lowest threshold is quite small.

The amplitude spread for the 90 % of cases of normal distribution (Figure 3) is 0.20 μ for 70 cycles; 0.06 μ for 120 cycles; 0.07 μ for 240 cycles; 0.18 μ for 480 cycles and 0.21 μ for 960 cycle frequency. The 120 and 240 cycle frequencies are characterized by low mean thresholds and very narrow amplitude ranges in contrast to the more than doubled amplitude ranges of the other tested frequencies.

Grouping of the subjects by handedness reveals that right handed individuals are more sensitive on the left index fingertips and conversely, that left handed individuals have lower thresholds on the right index fingertips. This latter phenomenon persists even though the left handed subjects have been completely trained to right handed activity. Moreover, the threshold values for both hands on left handed subjects are appreciably higher than those found in right handed individuals throughout the entire range of tested frequencies (Table 2). The significance of this observation is unknown.

REPEATED TESTING

Variations found on repeated testing of the same individual are shown in Table 3. The intervals between testing were irregular and occurred during all seasons of the year.

An appreciable fluctuation is shown in some subjects (cases 6-10-14) on repeated testing; *all of the readings however, remain within the normal range.* The least variation is found at the 240 cycle frequency; the greatest deviations are noted at both ends of the spectrum.

There is some evidence, based on preliminary investigation, that smoking shortly before testing will cause a decrease in the threshold at all frequencies for about one hour while exposure to cold atmosphere for even a short period within 30 minutes prior to the test, will tend to raise the threshold to maximum normal values. It is possible that these factors were responsible, at least in part, for the fluctuations noted on repeated testing of normal subjects.

DISCUSSION

Since 1928 vibratory generators employing vacuum tube oscillators with radio loud speaker motors as well as instruments whose frequencies were controlled by piezo-electric crystals, have been used to drive probes delivering mechanical stimuli to the skin surface (15–18, 20–26, 28, 30–32). Evaluation of probe amplitudes as a function of applied voltages has been supplemented, in a number of instances, by the use of optical systems in which the excursion of the probe is measured with the low power microscope, through photography or by means of a stroboscope. Many of these instruments were calibrated in arbitrary units which could not be converted to any standard measurement for comparative purposes.

The upper and lower limits of vibration frequency perceptible to the human have not been clearly defined. All authorities, however, except Dunlap (27),

agree that vibrations from 64 to 1024 c.p.s. are undoubtedly within the perceptible range.

The threshold amplitude ranges at various frequencies for different pressures and wave forms at the various test sites has been the subject of much controversy.

It appears that much of the disagreement as to threshold amplitudes and optimum frequencies in the literature (16, 20, 22, 26, 28–34) stems from the selection of inappropriate test subjects as well as technical differences in test apparatus. A number of very common diseases without known neurologic components, e.g. acne vulgaris, contact dermatitis, pityriasis rosea, etc. have been shown to yield normal vibratory threshold amplitudes at 120 and 240 c.p.s. and to have distinctly abnormal threshold values at the other tested frequencies (35).

For the entire range of tested frequencies the curves for normal described here have the lowest recorded amplitudes although a number of authors have published similar values for some of the single frequencies.

SUMMARY AND CONCLUSIONS

A new electronic instrument, the "Pallometer" is described for the precise determination of threshold amplitudes of vibratory appreciation at any selected fixed frequencies. Minute deviations in amplitude levels can be accurately ascertained.

Pallometric threshold patterns for the fingertips in 60 proved normal subjects of varying ages and both sexes are presented. Individuals with normal vibratory acuity report differing threshold amplitudes at the various frequencies tested. Amplitude spreads are confined to the narrowest limits so far reported. The form of the mean curve confirms 240 c.p.s. as the optimum frequency and reveals a very small elevation from this level at frequencies on either side.

Right-handed individuals are shown to be more sensitive on the left index fingertip; left-handed subjects are more sensitive on the right. Left-handed subjects however, have higher threshold levels on both hands.

Repeated testing of normal individuals reveals fluctuations within the limits of the normal amplitude range. Threshold amplitudes apparently are easily influenced by changes in environmental temperature and by the smoking of a single cigarette.

Determination of normality of vibratory acuity based upon levels of appreciation at 1 or 2 frequencies may be misleading.

It is essential that only subjects with proved normal vibratory acuity be used as controls for vibratory sense studies.

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